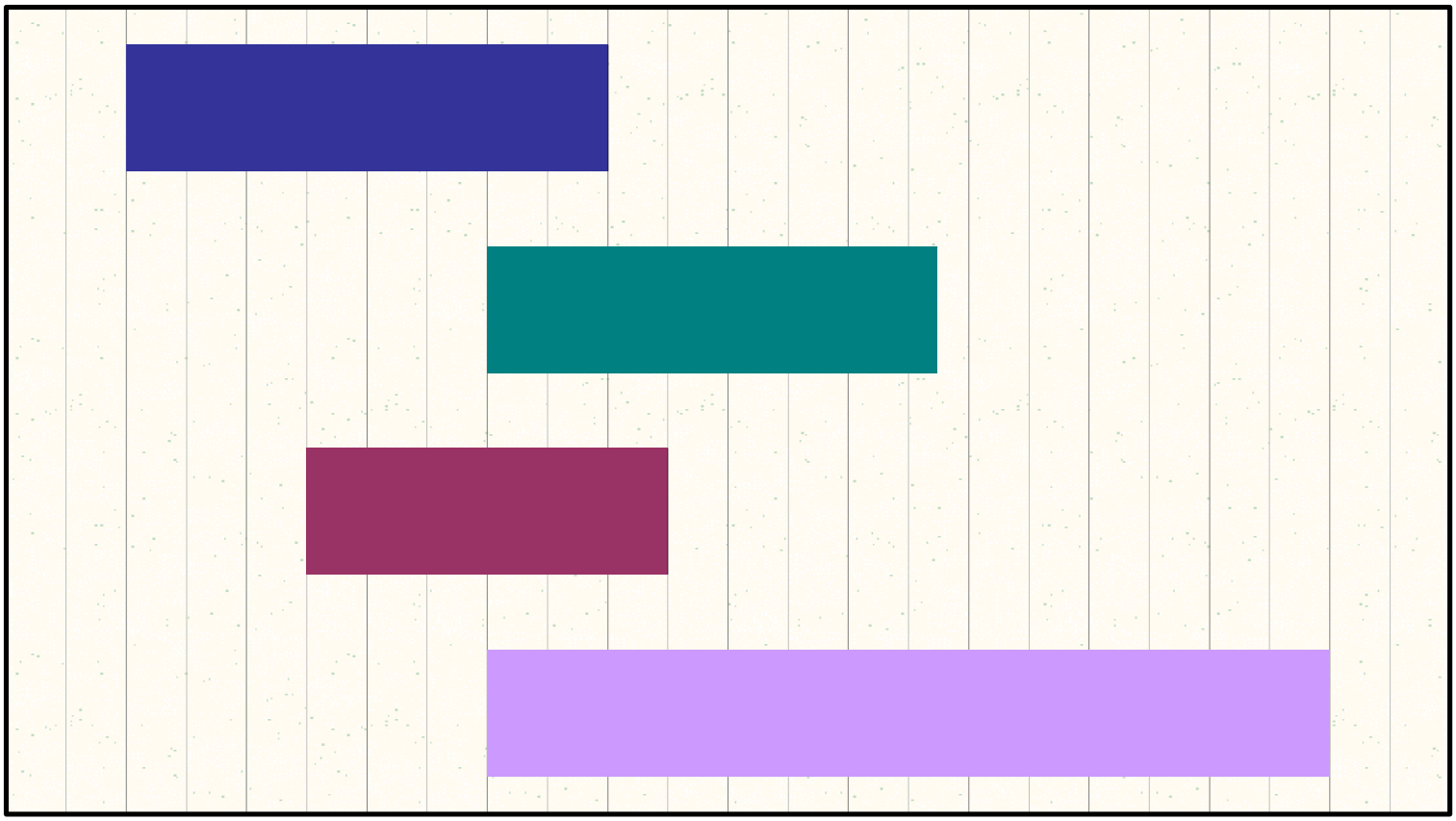
IRON CASTING PROCESS COMPARISON



Austin GROUP, LLC

A Qualitative Comparison of Several Competing Processes for the Production of Iron Castings

The following charts are intended to provide a relative guide to compare various iron casting methods. It is important to note that, the actual costs and casting results will vary significantly for any given project. The complexity of the part, the number of cores or pulls, the engineering and design time and customer requirements will all have a significant impact on the cost to produce a part with any of the compared methods. An attempt to provide specific comparison data for a given part would be highly sensitive to that particular part. Therefore, a composite of existing source data including foundry results, professional society literature, equipment manufacturer comments and personal experience was used to generate the comparison charts. Foundries, foam molders and tool builders contributed to the collection of the data.

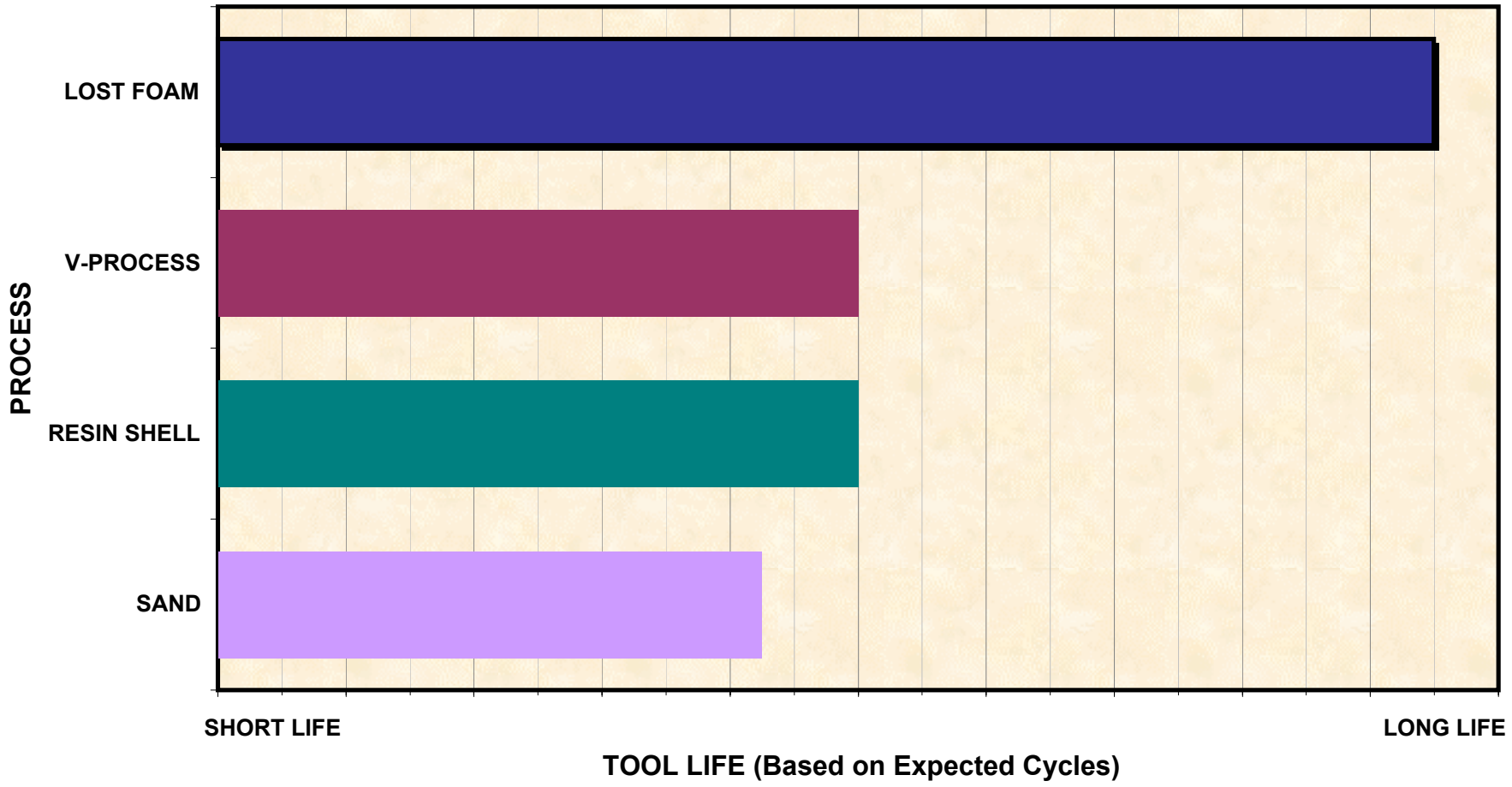
IRON CASTING PROCESSES - COMPARISON MATRIX

PROCESS	DESCRIPTION	TYPICAL SIZE RANGE	TOLERANCES	SURFACE FINISH	MINIMUM DRAFT REQUIRED	MINIMUM SECTION THICKNESS	TYPICAL ORDER QUANTITIES	TYPICAL TOOLING COSTS	NOMINAL LEAD TIMES
LOST FOAM	A metal mold is used to produce foam patterns Foam patterns are invested in sand. Molten metal is poured on to the foam patterns throug gating. The foam evaporates and is replaced b metal.	Ounces up to 1000 lbs.	± .007" to 1" ± .010 1-3" then add ±.003"/inch	125-350 RMS	1/4 to zero degrees	.150"	All	$8000 to $120000	Samples: 3 to 8 weeks Production: 6 to 18 weeks
SAND CASTING	Treated sand is molded around a wood or meta pattern. The mold halves are opened and the pattern is removed. Metal is poured into the cavity. The mold is broken and the casting is removed	Ounces up to tons	± .03" to 6" then add ±.003"/inch Add ±.020" to .090" across parting line	200-550 RMS	1 to 5 degrees	.25"	All	$1000 to $10000	Samples: 2 to 6 weeks Production: 2 to 6 weeks
RESIN SHELL MOLDING	Resin-coated sand is poured onto hot metal patterns, curing into shell-like mold halves. These are removed from the pattern and assembled with or without cores. Metal is poured into the resulting cavities. Molds are broken to remove castings.	Ounces up to 100 lbs.	± .008" to 1" ± .010" 1-3" then add ±.002"/inch	200-350 RMS	1/2 to 2 degrees	.125"	1000 and up	$3000 to $20000	Samples: 6 to 8 weeks Production: 8 to 12 weeks
V-PROCESS CASTING	Sand is "Vacuum-packed" around pattern halves. The pattern is removed and metal is poured into the cavity. The vacuum is released and the casting is removed	Ounces up to 150 lbs.	±.010" to 1" then add ±.002"/inch. Add ±.020" across parting line	125-250 RMS	1/2 to zero degrees	.125"	All	$3000 to $30000	Samples: 3 to 6 weeks Production: 3 to 6 weeks

IRON CASTING PROCESS COMPARISON

TOOL LIFE

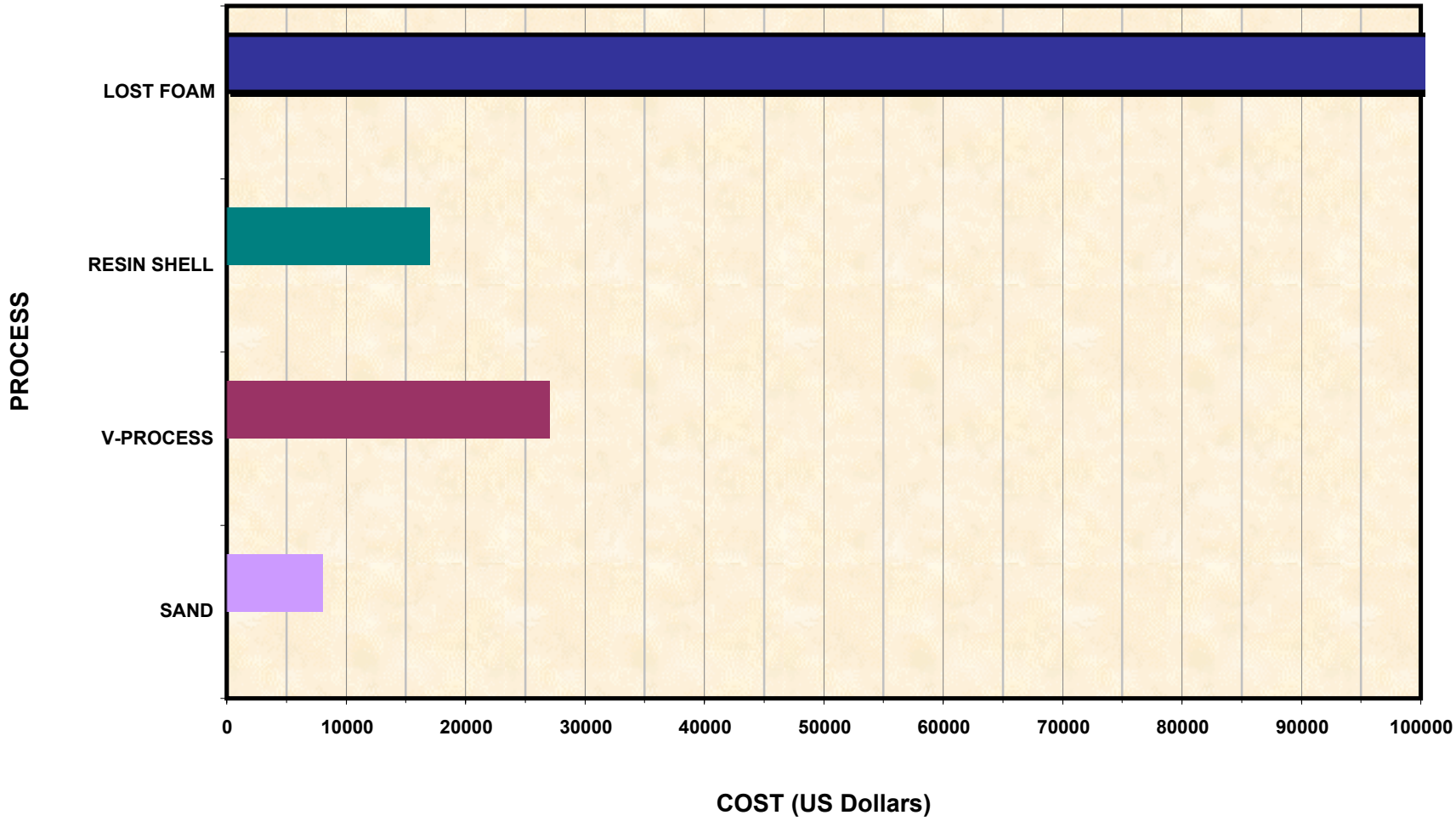
Length of tool life is one of the strongest aspects of the Lost Foam process. Life expectancy of Lost Foam tooling is in the hundreds of thousands cycles range with only low-level maintenance requirements. The V-process, resin shell and sand casting processes offer intermediate tool life but also require increased dimensional tolerances due to pattern wear.



IRON CASTING PROCESS COMPARISON

TOOL COST

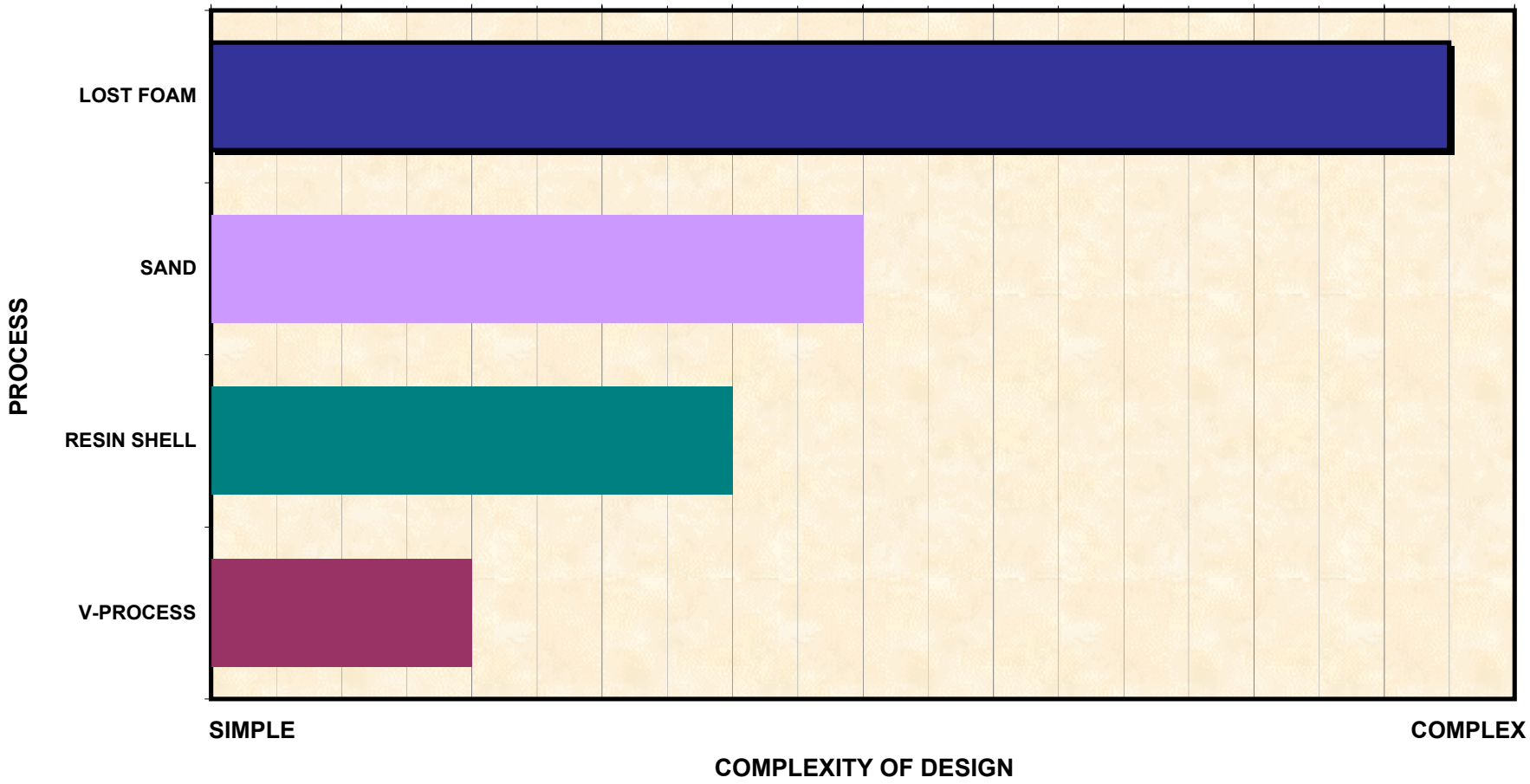
Conventional sand casting offers the lowest cost tool. The V-process and resin shell processes are comparable on simple tooling. The Lost Foam process allows a wide range of simple to very complex parts resulting in the wide tool cost range.



IRON CASTING PROCESS COMPARISON

COMPLEXITY OF DESIGN

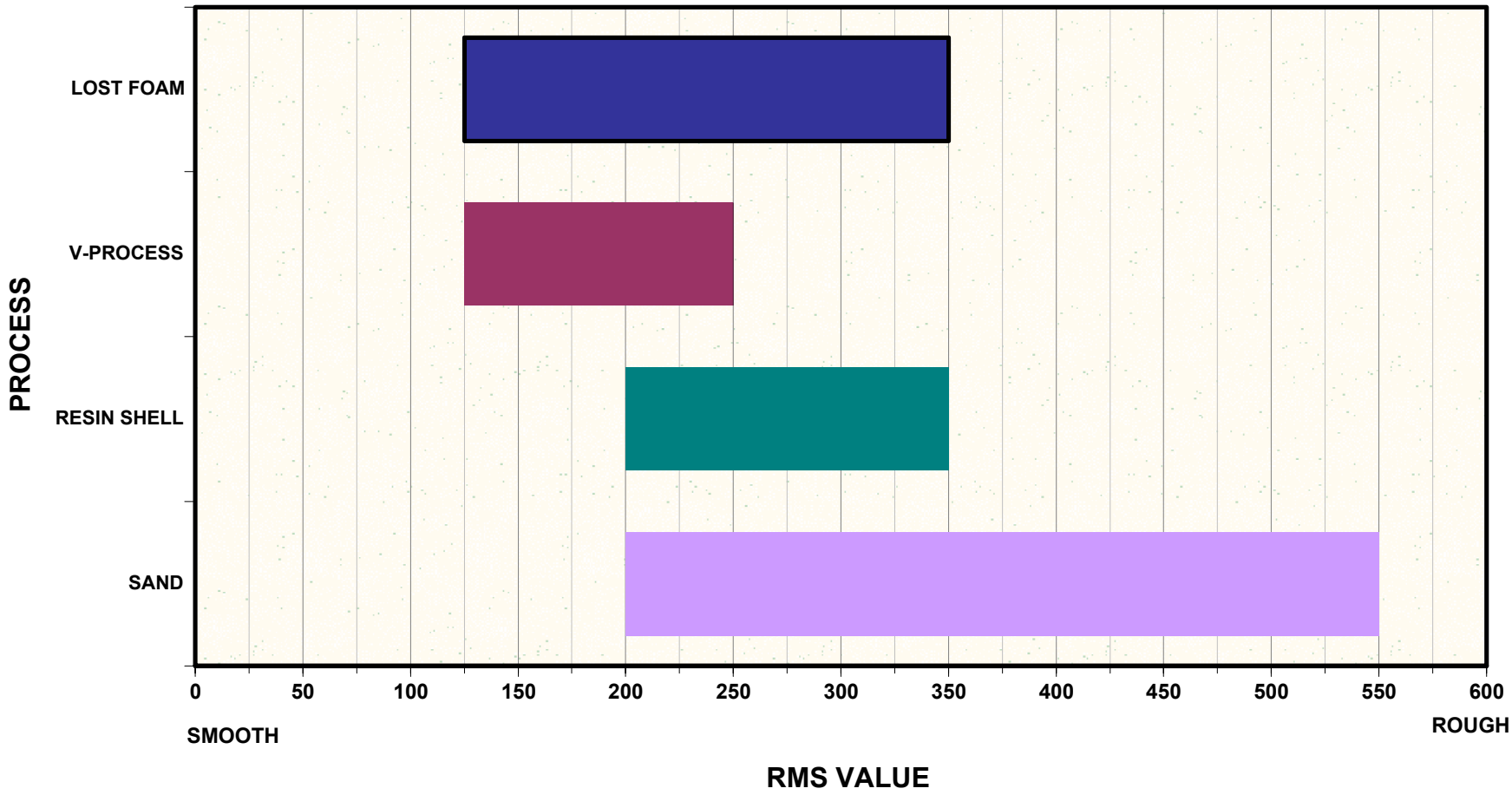
The Lost Foam process will allow the most complex part designs of all the methods. Foams can be assembled and glued together to produce exceptionally complicated castings, often combining two or more castings into one piece. Sand casting and methods with their use of cores allow the next highest level of complexity. Resin shell castings can have cores similar to sand but assembly methods make coring more difficult. V-process castings typically do not use cores and are simpler.



IRON CASTING PROCESS COMPARISON

RELATIVE SURFACE FINISH

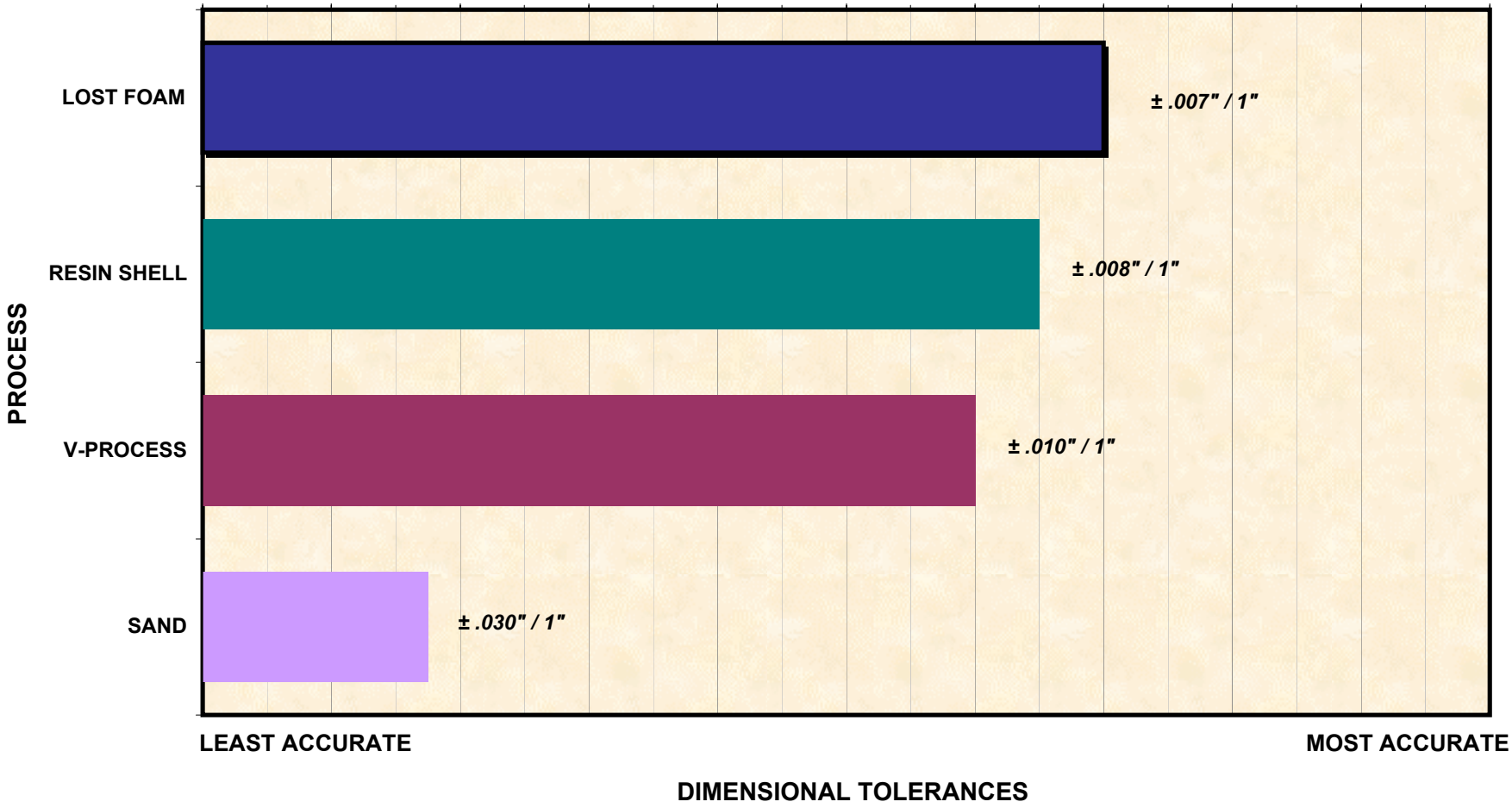
A wide range of surface finishes are produced by the various casting methods. Green sand casting is expected to produce the worst surface finish. The V-process typically produces good, consistent results when patterns are new. Resin shell castings are similar in surface finish to sand castings with slightly less variance. The Lost Foam casting surface is comparable to V-process and the surface finish will be consistent throughout the tool life cycle.



IRON CASTING PROCESS COMPARISON

DIMENSIONAL TOLERANCES

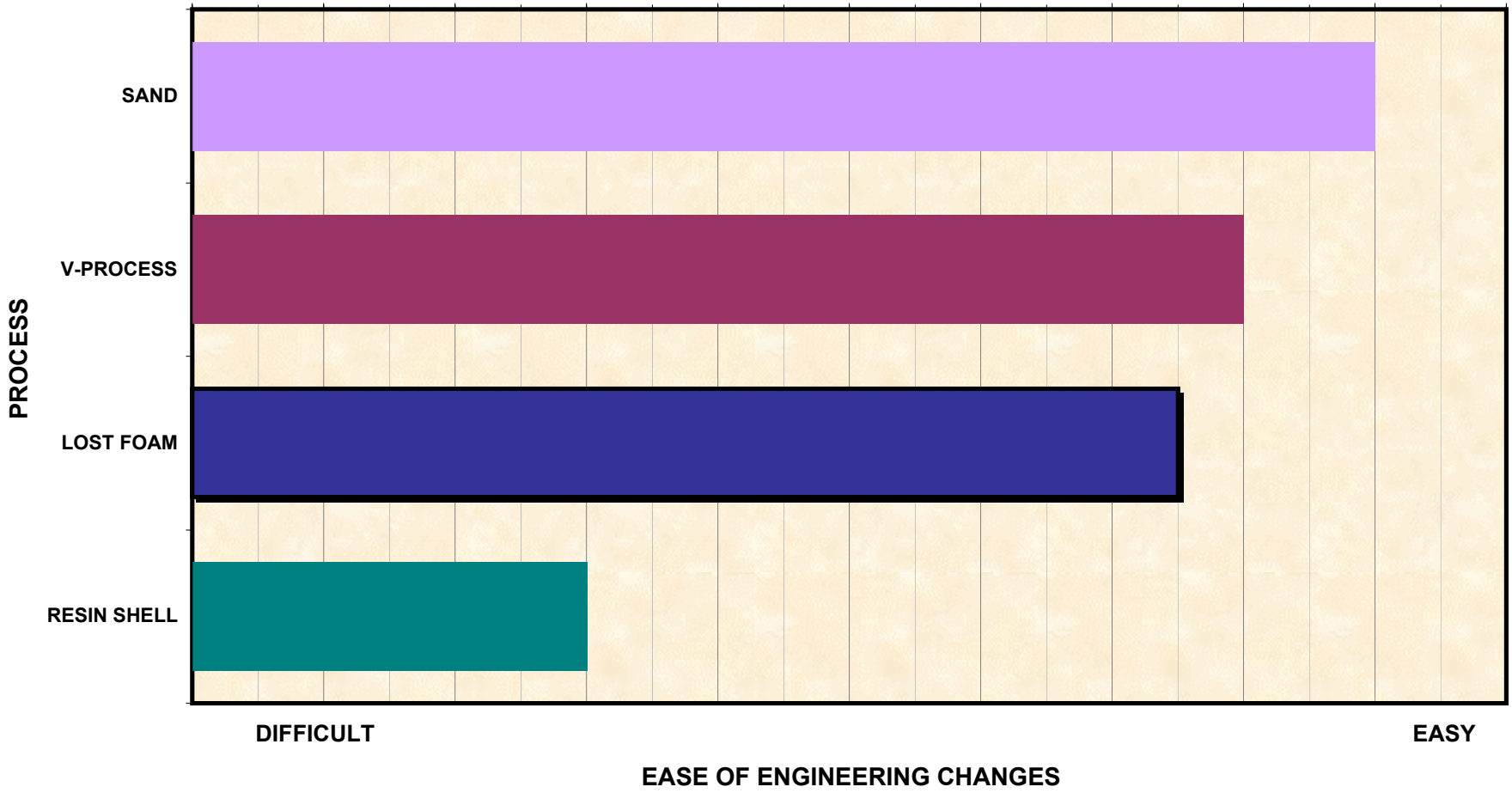
The Lost Foam process will typically yield the best dimensional tolerances with resin shell a close second. V-process is comparable to Lost Foam but is subject to pattern wear. Sand castings are expected to yield the least accurate results of the various methods.



IRON CASTING PROCESS COMPARISON

EASE OF ENGINEERING CHANGES

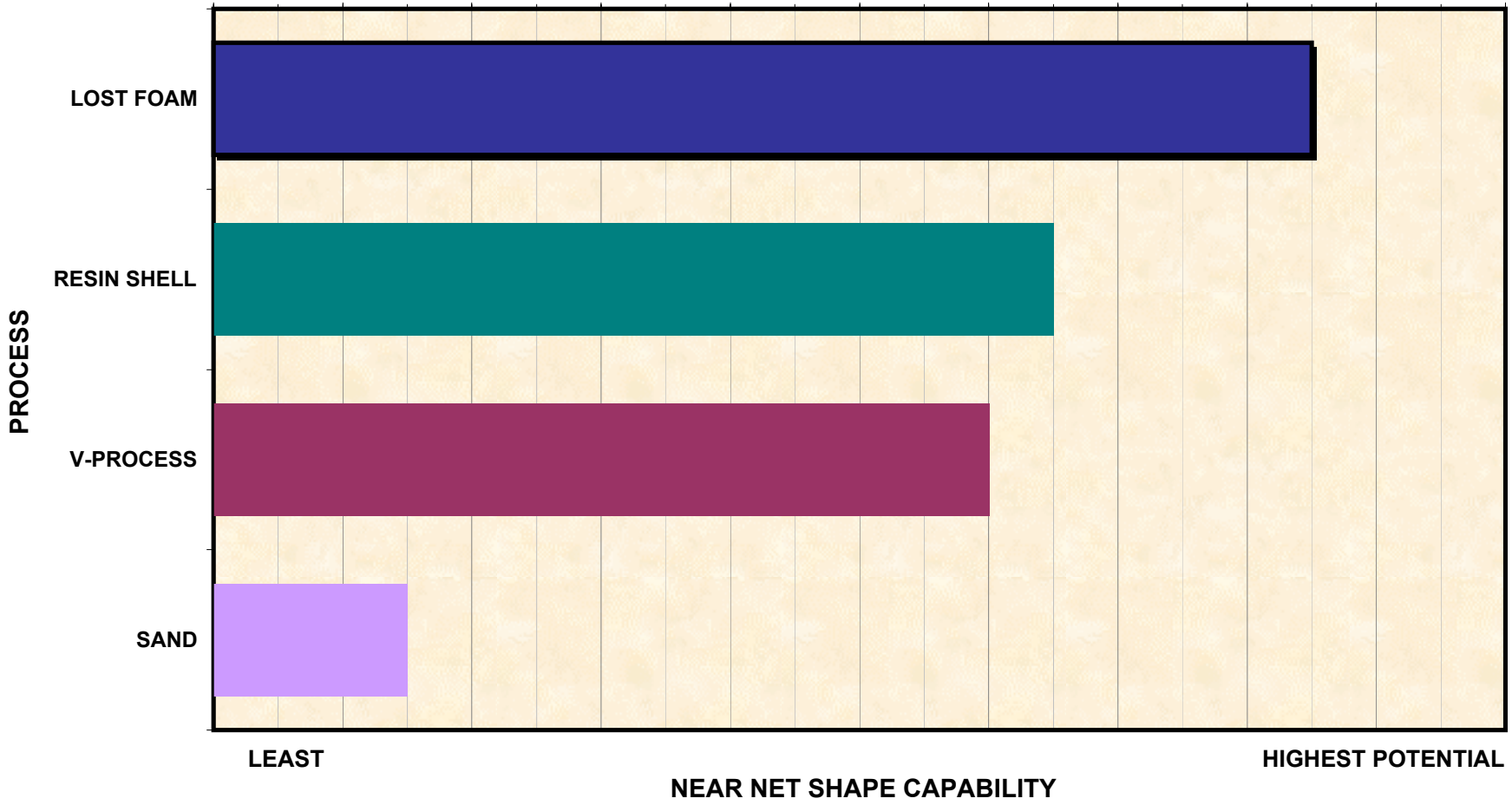
Engineering or tooling changes are expected to be easiest to in the sand casting process, where aluminum or wood patterns are used. The V-process also allows relatively easy changes due to pattern material. The Lost Foam process use of CNC-cut aluminum tooling means tool changes require more design coordination but changes are still made quickly. Metal resin shell patterns require the most work to change because of the difficulty in machining and welding iron.



IRON CASTING PROCESS COMPARISON

NEAR NET SHAPE CAPABILITY

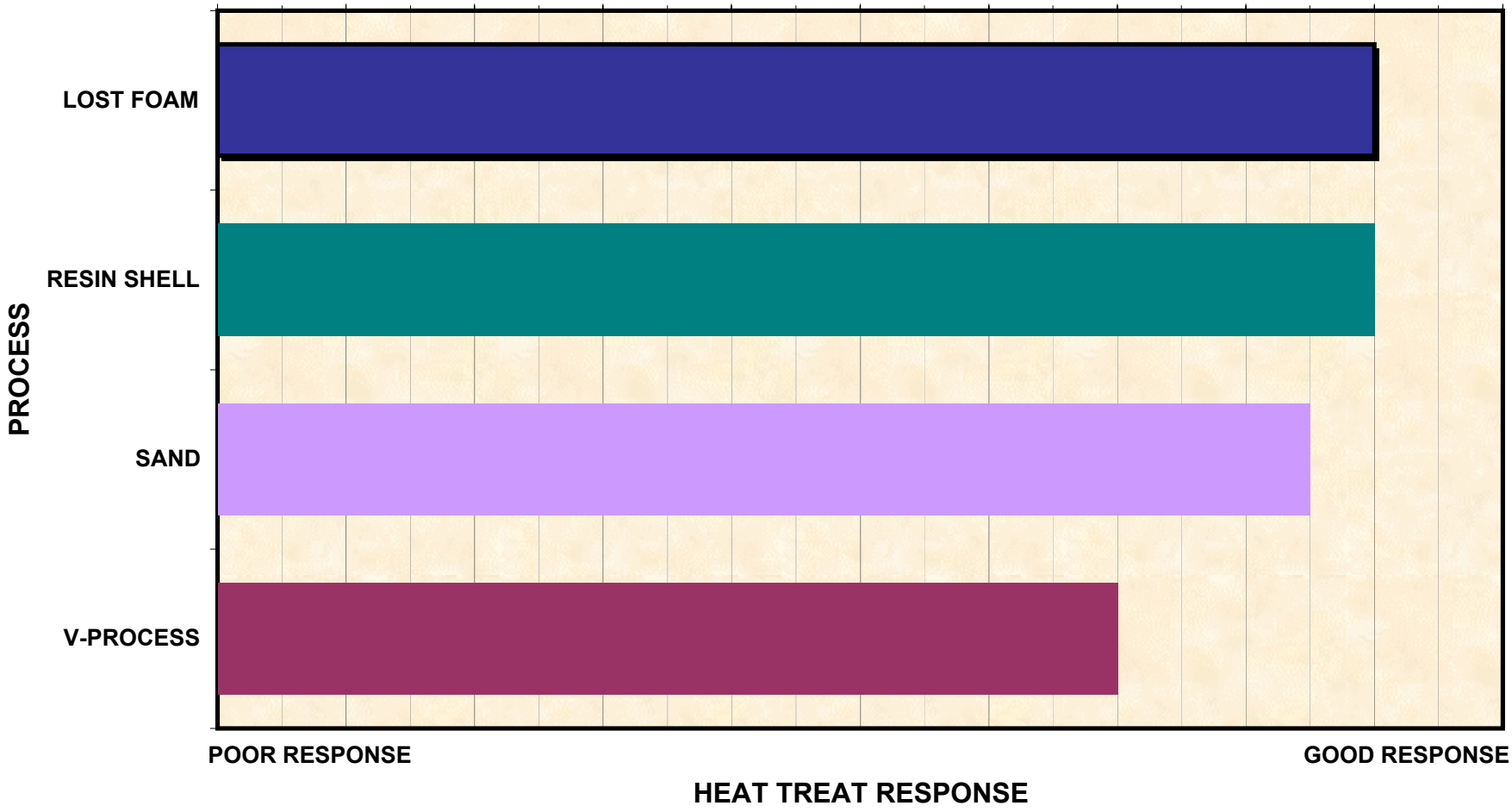
The combination of a good surface finish, dimensional accuracy and added features make the Lost Foam process well suited to achieve near net shape castings. The resin shell process will also produce good results. V-process patterns are subject to wear but produce good results in low volumes. Green sand methods have the least potential for producing near net shape castings.



IRON CASTING PROCESS COMPARISON

HEAT TREAT RESPONSE

Heat treatment response will be comparable between the Lost Foam, conventional sand and resin shell processes. V-process castings are expected to respond slightly poorer to heat treatment, but still with satisfactory results.



IRON CASTING PROCESS COMPARISON

INTERNAL METAL SOUNDNESS

The Lost Foam processes has demonstrated the best internal metal soundness. The process has smooth metal flow characteristics resulting in less gas entrapment during pouring. The lack of cores or sand bonding media in the Lost Foam process eliminates gas absorption from the mold during solidification. By contrast, the V-process, resin shell and san processes use cores and bonding material that will contribute to porous metal conditions.